Missouri Department of Natural Resources

BIOLOGICAL ASSESSMENT

Big Muddy Creek
Daviess County

2004-2005

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Field Services Division
Environmental Services Program
Water Quality Monitoring Section

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**), Water Protection Program (**WPP**), the Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate bioassessment and habitat study of Big Muddy Creek in Daviess County in north central Missouri. Approximately 8 miles of Big Muddy Creek are included on the 2002 303(d) list for sediment pollution from agricultural nonpoint sources. Although habitat loss is not an impact found on the 303(d) list, there are segments of Big Muddy Creek that have extensive channelization, vertical banks, and poor riparian zones. This survey assessed the Big Muddy Creek from SE ¼, Section 36, Township 59 North, Range 27 West, at the confluence of the Grand River, to NE ¼, Section 33, Township 60 North, Range 27 West. The eight (8) miles of Big Muddy Creek addressed in this study are listed as Class P waters (MDNR 2000), waterbody I.D. #0436.

1.1 Purpose

The purpose of the study was to determine if the Big Muddy Creek biological community is impaired and, if so, determine potential causes.

1.2 Objectives

1) Define the habitat characteristics of upper Big Muddy Creek.
2) Define the water quality characteristics of upper Big Muddy Creek.
3) Determine if the macroinvertebrate community and water qualities of upper Big Muddy Creek are affected by factors related to habitat.

1.3 Tasks

1) Conduct a bioassessment of the macroinvertebrate community of upper Big Muddy Creek.
2) Conduct a water quality assessment of upper Big Muddy Creek.
3) Conduct a habitat assessment of upper Big Muddy Creek.

1.4 Null Hypotheses

1) Macroinvertebrate assemblages will not substantially differ between Big Muddy Creek and biocriteria reference streams within the Plains/Grand/Chariton Ecological Drainage Unit (EDU).
2) Macroinvertebrate assemblages and habitat will not differ among Big Muddy Creek stream segments.

2.0 Study Area

The headwaters of Big Muddy Creek lie in an area between the cities of Gilman City and Jameson in northern Daviess County. It flows in a southerly direction to its confluence with the Grand River, approximately 5 miles southeast of Gallatin. The entire drainage of the creek is approximately 117 square miles.

Northern Missouri landforms are the result of glaciation and consist of plains and low rolling hills. Agriculture is a major industry in northern Missouri, including row crops and concentrated animal feeding operations. In many cases row crops are planted to the edge of stream banks, thereby decreasing the quality of the riparian zone and leading to unstable banks and a loss of

woody debris input to the stream, which in turn results in a loss of habitat. Many of the larger streams and rivers in northern Missouri have been channelized to provide more area in the river bottoms for cropland. Channelization causes a loss of channel structure, which would normally promote the formation of good quality habitats.

2.1 Site Descriptions

Three stations were chosen along Big Muddy Creek. Each station represents stream conditions locally and for an area approximately 4-5 miles upstream. See Figure 1 for a map of the study stations.

Big Muddy Creek Station 1: (N ½ Section 36, Township 59 North, Range 27 West). Station 1 is located at the lower (southern end) of the stream reach. The lower end of the sampling station is immediately upstream of Ridge Avenue Bridge. It has a poor riparian zone with crops planted to the edge of the stream bank, is considered channelized, and has a shifting sand stream bottom. Geographic coordinates for this study station are Latitude 39.882472 and Longitude –93.877805.

Big Muddy Creek Station 2: (SW ¼ Section 11, Township 59 North, Range 27 West). Station 2 is located approximately 3.9 miles upstream from Station 1. The lower end of the sampling station begins approximately 150 yards upstream from the Highway 6 Bridge. It has a poor riparian zone with crops planted to the edge of the stream bank, is considered channelized, and has a shifting sand stream bottom. Geographic coordinates for this study station are Latitude 39.933222 and Longitude –93.895638.

Big Muddy Creek Station 3: (NE ¼ Section 33, Township 60 North, Range 27 West). Station 3 is located approximately 3.8 miles upstream from Station 2. The lower end of the sampling station was a significant distance downstream from the 250th Street Bridge. It has a poor riparian zone with crops planted to the edge of the stream bank, is considered channelized, and has a shifting sand stream bottom. Geographic coordinates for this study station are Latitude 39.975055 and Longitude –93.936.

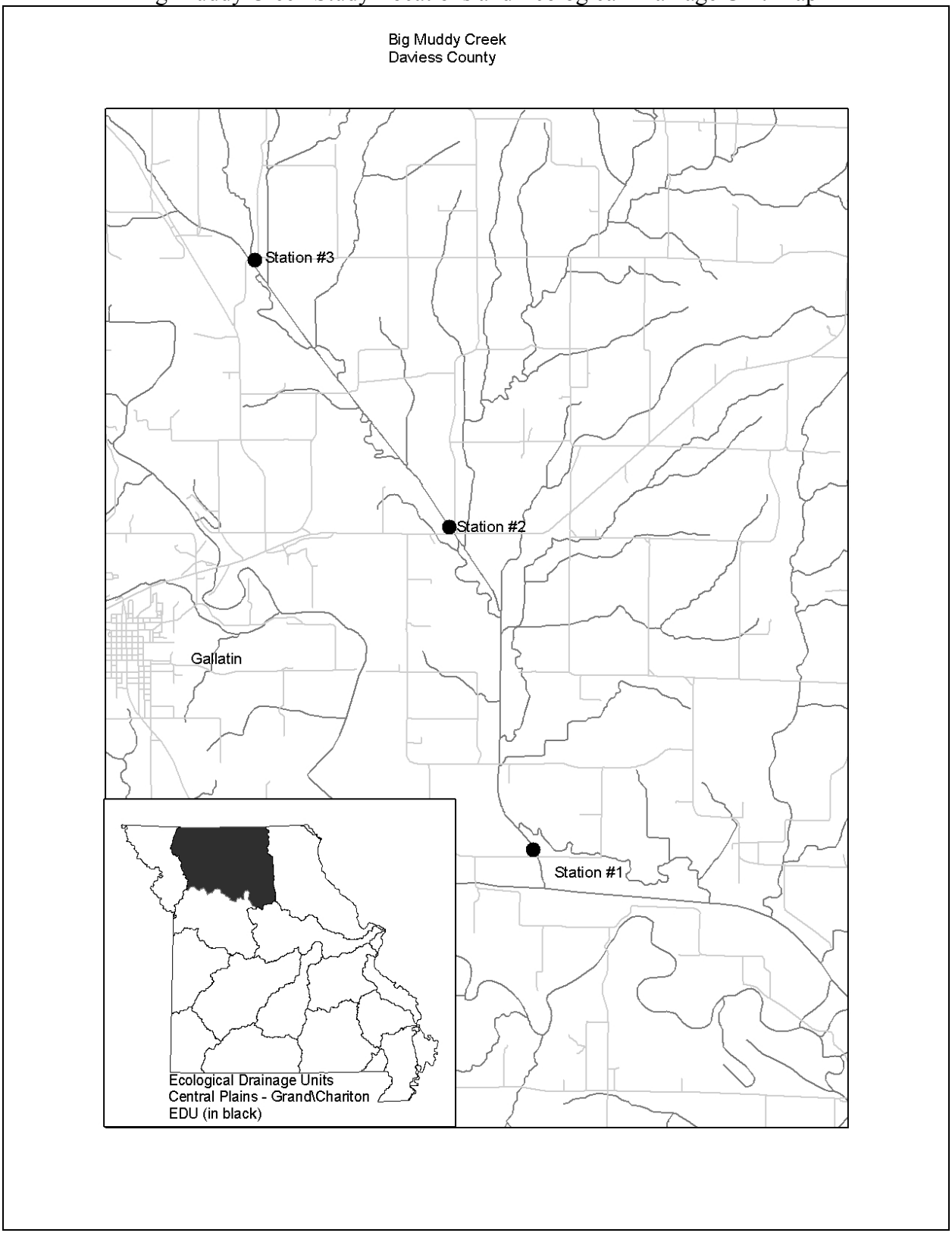
3.0 Methods

Randy Sarver, Ken Lister, Dave Michaelson, and other staff of the Missouri Department of Natural Resources, Environmental Services Program conducted this study. Sampling was conducted during the fall of 2004 and the spring of 2005. Fall sampling was conducted on September 15 and 16, 2004 and consisted of macroinvertebrate sampling, water quality sampling, habitat assessments, and channel dimension measurements. Spring sampling was conducted on March 22, 2005 and consisted of macroinvertebrate and water quality sampling.

3.1 Habitat

Big Muddy Creek was 303(d) listed for stream habitat degradation from excessive sedimentation. No suspended sediment data exists to directly document sediment as a significant impact to the stream. General fisheries data and the effect of sediment upon fish were the initial data to consider Big Muddy Creek for 303(d) listing. Sedimentation is one of many instream habitat problems associated with land use. Although instream habitat can be directly measured, the causes of the degradation can range from local scale sources to watershed scale sources.

Figure 1
Big Muddy Creek Study Locations and Ecological Drainage Unit Map



Habitat measures were collected at the watershed scale, reach scale, and habitat scale to allow evaluation of instream habitat conditions and to better associate those conditions with sediment.

3.1.1 Land Use

The land use conditions were summarized from land cover GIS files. These land cover files were provided by the Missouri Resource Assessment Partnership (MoRAP) and derived from 1991-1993 LANDSAT data.

3.1.2 Habitat Assessment

A standardized assessment procedure was followed as described for Glide/Pool Habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2003b). The habitat assessment was conducted on Big Muddy Creek during the September 2004 sample season.

3.1.3 Sinuosity

Sinuosity was used as an indicator of the amount of channelization that had taken place. Using the National Hydrography Dataset (**NHD**) and Arcmap software, the sampling station was placed in the approximate middle of a two-mile stream segment and sinuosity was measured by calculating the ratio of the stream length distance divided by the straight-line distance.

3.1.4 Channel Measurements

Lack of instream habitat can be observed in northern Missouri streams that are wide and shallow. Wider, shallower streams tend to have less ability to retain pools and woody debris (Haithcoat et al. 2003). At each sampling station a series of 10 bank to bank transects were established. Each transect was equally spaced within the sampling reach, which is 20x the average width. Measurements taken at each transect included lower bank width (see the Stream Habitat Assessment Procedure for a definition of Lower Bank), wetted width, and water depth at ¼, ½, and ¾ of the distance across the wetted width. In order to document critical habitat conditions, measurements were collected during the fall low flow period.

3.2 Physicochemical Water Parameters

Physical and chemical water samples were collected from all stations during both fall and spring. Parameters collected were nitrate+nitrite-nitrogen, ammonia-nitrogen, Total Kjeldahl Nitrogen, chloride, turbidity, temperature, conductivity, dissolved oxygen, pH, and discharge. WQMS personnel analyzed temperature, conductivity, dissolved oxygen, pH, and discharge in the field and turbidity in the biology laboratory. All other parameters were delivered to the ESP, Chemical Analyses Section for analyses. All samples were collected according to the standard operating procedure MDNR-FSS-001: Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2002b) and were recorded on an MDNR chain-of-custody (MDNR 2001).

3.3 Biological Assessment

The biological assessment was conducted according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2003a). All stations were sampled in September 2004 and March 2005. Three standard habitats of glide/pool streams (e.g. large woody debris substrate, depositional substrate in non-flowing water, and rootmat substrate) were sampled at all locations.

Macroinvertebrate data were evaluated by comparison to Biological Criteria for Perennial/Wadeable streams of the Plains/Grand/Chariton Ecological Drainage Unit (**EDU**). An EDU is an ecological area in which the aquatic biological communities and stream habitat can be expected to be similar. See Figure 1 for a map of the EDU's of Missouri.

Biological criteria are calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The four core metrics of the MSCI are: Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered full biological sustainability, 10-14 is partial biological sustainability, and 4-8 is non-biological sustainability. Table 1 provides scoring criteria for the fall index period and Table 2 for the spring index period.

Table 1
Biological Criteria for Glide/Pool-Fall Index Period
Plains/Grand/Chariton EDU

Metric	Score = 1	Score = 3	Score = 5
TR	< 26	26 – 51	> 51
EPTT	< 4	4 – 9	> 9
BI	> 8.60	8.60 – 7.20	< 7.20
SDI	< 1.34	1.34 – 2.68	> 2.68

Table 2
Biological Criteria for Glide/Pool-Spring Index Period
Plains/Grand/Chariton EDU

Metric	Score = 1	Score = 3	Score = 5
TR	< 25	25 – 50	> 50
EPTT	< 4	4 – 8	> 8
BI	> 8.62	8.62 – 7.24	< 7.24
SDI	< 1.27	1.27– 2.53	> 2.53

4.0 Results and Analyses

4.1 Land Use

The Big Muddy Creek drainage basin, which is the subject of this report, is comprised of mainly row crops and grasses. Table 3 provides two scales of land use comparison. Comparing the 14-digit hydrologic units (**HU**) for Big Muddy Creek stations with the Plains/Grand/Chariton EDU provides comparable sized units for comparison. A watershed comparison is provided by comparing the 14-digit HU for Big Muddy Creek stations with the 14-digit HU of three nearby wadeable/perennial biocriteria reference streams (**BIOREF**) in the EDU. Big Muddy Creek HU values in bold are those that potentially indicate poorer land use. Muddy Creek HU's have greater amounts of row crop agriculture.

Table 3 – Land Cover

Watershed	14-Digit HU	% Urban	% Row Crops	% Grassland	% Forest
Plains/Grand/Chariton EDU	NA	0.2	30.3	53	15.2
Big Muddy Creek Station 1 & 2	10280101180003	0.2	**46.5**	44.2	8.6
Big Muddy Creek Station 3	10280101180001	0.2	**43.1**	46.1	10.2
BIOREF Marrowbone Creek	10280101170001	0.6	24	61.3	13.6
BIOREF West Fork Big Creek	10280101150003	0	14	64.4	21.3
BIOREF East Fork Grand River	10280101060008	0	23.4	61.4	14.9

4.2 Habitat Assessment

The results of the habitat assessment are found in Table 4. Big Muddy Creek Station 2 is ranked lowest (64) and Station 3 the highest (75). In the SHAPP, $\geq$ 75% similarity is the guidance for considering habitats comparable between reference and test stations. Comparable habitats should be able to support comparable biological communities. Both Big Muddy Creek Station 1 and Station 2 score below 75% similarity when compared to the East Fork Grand River reference habitat score.

Table 4
Big Muddy Creek Habitat Assessment Scores

Station	Habitat Assessment Score	Percent of Reference
Big Muddy Creek 1	66	69%
Big Muddy Creek 2	64	67%
Big Muddy Creek 3	75	79%
East Fork Grand River (Ref)	95	

4.3 Sinuosity

Sinuosity measurements near 1 are considered potentially channelized. The sinuosity of Big Muddy Creek ranges from 1.02 to 1.06. The likelihood of channelization is based on the sinuosity and visual inspection of aerial photographs. Table 5 (Station Reach Characteristics) lists sinuosity characteristics for each sample station.

Table 5 – Station Reach Sinuosity

Station	*Sinuosity	Stream Length Used for Sinuosity (miles)	Likely to be Channelized
1	1.06	2.04	Yes
2	1.02	2.05	Yes
3	1.03	2.03	Yes

4.4 Channel Measurements

Station transect measurements for lower bank channel width, wetted width, and depth are provided in Appendix D.

In normal circumstances channel measurements, such as average channel width, reflect the fact that the stream width increases with increasing watershed size. The Big Muddy Creek study shows a clear progression in channel width data (Table 6) with the most upstream station (3) at 34.7 feet and the most downstream station (1) at 62.8 feet.

Other channel measurements, such as average depth, average wetted width, maximum depth, and standard deviation of depth do not necessarily reflect trends associated with size. These measurements indicated greater water volume by documenting the fact that water is deeper, depths are more heterogeneous, and water potentially takes up more of the width of the stream. In the case of Big Muddy Creek, all of these channel measurements gradually increase with an increase in the watershed size.

In order to be able to do comparisons of stream stations in a longitudinal stream study it is sometimes necessary to incorporate ratios of measurements. Ratios can standardize measurements so that data such as channel width can be used in a manner that allows comparison of study stations regardless of their longitudinal placement. The ratios of channel width/wetted width and wetted width/average depth are given in Table 6. These ratios potentially reflect the wide shallow characteristics of the stream, which result in poorer habitat. The ratio of channel width to wetted width is greatest at Station 2, which indicates a smaller wetted channel in a wider bank to bank channel. The ratio of wetted width to depth is greatest at Station 1, which indicates a wider shallow nature, especially when examined in conjunction with the average depth.

Table 6 – Stream Width and Depth Measurement Summary

Big Muddy Creek Station	Avg. Channel Width (ft)	Avg. Wetted Width (ft)	Avg. Depth of stream (ft)	Maximum Depth (ft)	Ratio Channel Width to Wetted Width	Ratio Wetted Width to Depth	Standard Deviation of Depth
1	62.8	47.7	0.9	1.83	1.3	55.8	0.41
2	49.2	25.9	0.6	1.17	1.9	46.5	0.24
3	34.7	22.6	0.5	1.5	1.5	41.7	0.33
Reference	45.7	25.1	0.9	**2.7**	1.7	**27.5**	**0.7**

4.4.1 Comparison of Test Station and Reference Station Channel Measurements

Table 6 also includes mean channel measurement values for northern Missouri reference streams (MDNR 2005). Although no statistical comparison is performed as part of this report, a visual comparison demonstrates some differences between reference streams and Big Muddy Creek stations. Average reference measurements that are outside the range of all Big Muddy Creek values include maximum depths, ratio of wetted width to depth, and standard deviation of depth. These values indicate that all Big Muddy Creek sampling stations have shallower maximum depths, wider and shallower channels, and more homogenous water depths.

4.5 Physicochemical Results

Results from the fall 2004 sampling season can be found in Table 7 and the spring 2005 sampling season in Table 8.

No water quality standards violations were measured by grab sampling techniques during the time frame of this study. Big Muddy Creek Station 3 does have nitrogen and phosphorus water quality parameters that appear different from other stations during fall 2004. These parameters were at least twice the concentrations of the other two stations.

However, when turbidity, discharge, and field notes were examined, it was apparent that the fall sampling period was during a rainy period when stream discharge was in a state of flux. This indicates that rainfall, rather than watershed differences, may have been responsible for the differences in chemical parameters between Big Muddy Creek stations.

Nitrogen compounds, phosphorus, turbidity, and discharge values were all much lower for the spring sampling season, indicating that higher values are a result of run-off from non-point sources.

Table 7 – Fall 2004 Physicochemical Results

Sample Number	Station	Ammonia as N mg/L	Chloride mg/L	Dissolved Oxygen mg/L	Flow (cubic ft/sec)	Nitrate + Nitrite as N mg/L	pH	Specific Conductivity umhos/cm	Temperature Degrees C	Total Kjeldahl Nitrogen mg/L	Total Phosphorus mg/L	Turbidity NTU
0411659	Big Muddy Creek 1	< 0.03	9.55	7.98	21.4	0.09	7.6	369	18.5	0.69	0.25	62.7
0411657	Big Muddy Creek 2	< 0.03	9.09	7.3	6.81	0.02	7.8	421	23.5	0.53	0.22	45.3
0411658	Big Muddy Creek 3	< 0.03	11.6	7.11	19.3	**0.17**	7.6	314	22	**1.53**	**0.49**	**337**

Table 8 – Spring 2005 Physicochemical Results

Sample Number	Station	Ammonia as N mg/L	Chloride mg/L	Dissolved Oxygen mg/L	Flow (cubic ft/sec)	Nitrate + Nitrite as N mg/L	pH	Specific Conductivity umhos/cm	Temperature Degrees C	Total Kjeldahl Nitrogen mg/L	Total Phosphorus mg/L	Turbidity NTU
0502940	Big Muddy Creek 1	< 0.03	13.3	12.9	0.33	0.04	8.3	447	6	0.33	0.09	8.19
0502941	Big Muddy Creek 2	< 0.03	13.0	13.7	7.9	< 0.01	8.4	453	6	0.22	0.08	5.25
0502942	Big Muddy Creek 3	< 0.03	14.9	13.0	3.1	0.02	8.3	445	6	0.38	0.08	22.8

4.6 Biological Assessment

4.6.1 Macroinvertebrate Stream Condition Index Scores

The Big Muddy Creek metric results and MSCI scores for fall 2004 and spring 2005 are found in Table 9 and Table 10 respectively. MSCI scores are calculated by scoring station metrics against the appropriate criteria from Table 1 or Table 2. Big Muddy Creek MSCI scores indicate that all stream stations were ≥ 16, which are assigned full biological sustainability.

Table 9
Fall 2004 Macroinvertebrate Stream Condition Index Scores

Sampling Station	Big Muddy Creek 1-Metric	Big Muddy Creek 1-Score	Big Muddy Creek 2-Metric	Big Muddy Creek 2-Score	Big Muddy Creek 3-Metric	Big Muddy Creek 3-Score
Sample Number	0418724	0418724	0418722	0418722	0418723	0418723
Taxa Richness	68	5	84	5	72	5
EPT Taxa	15	5	18	5	14	5
Biotic Index	6.66	5	6.63	5	6.25	5
Shannon Index	3.12	5	3.23	5	3.06	5
SCI Score		20		20		20
Sustainability		Full		Full		Full

Table 10
Spring 2005 Macroinvertebrate Stream Condition Index Scores

Sampling Station	Big Muddy Creek 1-Metric	Big Muddy Creek 1-Score	Big Muddy Creek 2-Metric	Big Muddy Creek 2-Score	Big Muddy Creek 3-Metric	Big Muddy Creek 3-Score
Sample Number	0503007	0503007	0503008	0503008	0503009	0503009
Taxa Richness	58	5	59	5	54	5
EPT Taxa	6	3	11	5	7	3
Biotic Index	7.2	5	7.18	5	7.27	3
Shannon Index	2.54	5	2.88	5	2.77	5
SCI Score		18		20		16
Sustainability		Full		Full		Full

5.0 Discussion

5.1 Erosion Potential

Big Muddy Creek was originally 303(d) listed for sediment from agricultural non-point sources. Sediment load can be estimated using the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), version 2.01. The STEPL model was developed for the U.S. Environmental Protection Agency by Tetra Tech, Inc, May 2002. The model calculates soil loss in tons/year.

In a memorandum from the ESP to the WPP, dated June 4, 2003, northern Missouri reference streams were analyzed for erosion potential using the STEPL model. Using this model, northern Missouri reference stream watershed soil loss was estimated to range from 0.23-1.10 tons/year/acre. Using the STEPL model, soil loss potential was also calculated for the watershed of each Big Muddy Creek station (Table 11). The Big Muddy Creek stations (1-3) fell within the reference stream range. A definitive relationship does not exist between soil loss and aquatic community health and there are no criteria for judging the point at which impacts can be measured. The soil loss from Big Muddy Creek does not differ measurably as compared to reference streams from which biological criteria have been established.

Table 11 – Big Muddy Creek Watershed Soil Loss

Watershed	tons/year	acres	tons/year/acre
Big Muddy Creek 1	34867.3	77638	0.45
Big Muddy Creek 2	24134.2	46118	0.52
Big Muddy Creek 3	14033.1	23465	0.60

5.2 Big Muddy Creek Stream Segment

The overall bioassessment for the Big Muddy Creek segment covered by this study suggests no biological impairment. Exactly 100% of the MSCI scores are $\geq$ 16 (full biological sustainability).

Macroinvertebrates have been shown to have good relationships to amounts of depositional sediment (Zwieg and Rabeni 2001) in rock bottom streams. However, northern Missouri streams are largely composed of materials considered to be sediment (silt and sand) by many researchers. As in many northern Missouri reference streams, the bottom substrate of Big Muddy Creek is predominately sand. The results of this study suggest that Big Muddy Creek macroinvertebrate communities are very similar to reference streams. In addition, the soil loss potential in the Big Muddy Creek watershed is within the range of soil loss for reference streams. Depositional sediment does not appear to be a significant problem in Big Muddy Creek.

Although invertebrates are responsive to changes in substrate they may not be responsive to certain habitat problems. The lack of top predator fish has been shown to have good relationship to channelized streams and the resulting lack of pools (MDNR 2005). Although there is no current information available to ESP, Big Muddy Creek shows evidence of channelization and resultant shallow water depths. This evidence includes poor habitat scores at Stations 1 & 2, low sinuosity at all stations, and channel dimensions that are more extreme than those of reference streams.

6.0 Conclusions

Three null hypotheses were stated in the introduction: 1) macroinvertebrate assemblages will not substantially differ between Big Muddy Creek and biocriteria reference streams within the Plains/Grand/Chariton Ecological Drainage Unit (EDU); 2) macroinvertebrate assemblages will not differ among Big Muddy Creek stream segments; and 3) habitat will not differ among Big Muddy Creek stream segments.

Both null hypotheses concerning macroinvertebrates are accepted. The macroinvertebrate community of upper Big Muddy Creek did not fall below the MSCI biological criteria nor did stations differ longitudinally.

The null hypothesis concerning habitat differences between Big Muddy Creek stations is rejected. Stations 1 & 2 had habitat scores lower than 75% similar to reference in addition to stream channel characteristics that were different than reference.

7.0 Recommendations

1) Propose de-listing the 8 mile portion of Big Muddy Creek on the 303(d) list for sediment based on current macroinvertebrate bioassessment data.

2) Recognize the need for development and incorporation of satisfactory fish bioassessment protocols into the departments aquatic bioassessment program.

3) Conduct fish bioassessments of extensively channelized streams to further evaluate the relationship between protection of aquatic life designated use, habitat conditions, pool depths, and stream channel characteristics.

8.0 Literature Cited

Haithcoat, T.L., M.A. Urban, C.F. Rabeni, and K.E. Doisy. 2003. Biophysical evaluation of reference streams in Missouri: Final report for the Missouri Department of Natural Resources. University of Missouri-Columbia, Columbia, Missouri 65211. 87 pp.

Missouri Department of Natural Resources. 2000. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. Missouri Department of Natural Resources, Water Pollution Control Program, P.O. Box 176, Jefferson City, Missouri 65102. pp. 10-136.

Missouri Department of Natural Resources. 2001. Field Sheet and Chain of Custody Record. MDNR-FSS-002. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 8 pp.

Missouri Department of Natural Resources. 2002a. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources**.** 2002b. Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. MDNR-FSS-001. Missouri Department of Natural Resources, Environmental Services Program, Water Quality Monitoring Section, Jefferson City, Missouri. 26 pp.

Missouri Department of Natural Resources**.** 2003a. Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, Water Quality Monitoring Section, Jefferson City, Missouri. 24 pp.

Missouri Department of Natural Resources**.** 2003b. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, Water Quality Monitoring Section, Jefferson City, Missouri. 40 pp.

Missouri Department of Natural Resources. 2005. Channel Modification Analyses of Streams Listed on the 303(d) List for Sediment from Non-point Agriculture. Missouri Department of Natural Resources, Environmental Services Program, Jefferson City, Missouri. 6 pp.

Zweig, L.D. and C.F. Rabeni. 2001. Biomonitoring for deposited sediment using benthic invertebrates: a test on 4 Missouri streams. Journal North American Benthological Society 20(4): 643-657.

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Appendix A
Macroinvertebrate Bench Sheets
Fall 2004 & Spring 2005
(-99 = Present as Large/Rare)

Aquatic Invertebrate Database Bench Sheet Report

September 16, 2004 - Big Muddy Ck [0418724], Station 1

ORDER (Taxa)	RM	SG	NF
Gordiidae	1		
"HYDRACARINA"			
Acarina	5	1	1
AMPHIPODA			
Hyalella azteca	89	18	
COLEOPTERA			
Brachyvatus		1	
Hydroporus	6	2	-99
Dubiraphia	1		
DIPTERA			
Tipulidae	1		
Gonomyia			-99
Ormosia			1
Anopheles	1		
Forcipomyiinae		47	
Ceratopogoninae	1	1	14
Simulium		9	1
Ablabesmyia	6	5	11
Procladius		1	
Cricotopus bicinctus	1	1	
Cricotopus/Orthocladius		1	1
Nanocladius	1	1	
Thienemanniella		2	
Chironomus			2
Cryptochironomus			6
Dicrotendipes		31	3
Glyptotendipes		3	
Cryptotendipes	1		27
Phaenopsectra		1	
Polypedilum halterale grp			3
Polypedilum fallax grp		1	
Stenochironomus		4	
Polypedilum illinoense grp	20	23	
Polypedilum scalaenum grp	1	3	3
Cladotanytarsus	3	5	70
Paratanytarsus	6	6	2
Rheotanytarsus		2	
Stempellinella	1		6
Tanytarsus	43	99	46
Tabanus			1
Dolichopodidae		1	
Ephydridae		1	6
Muscidae	1		
Zavrelimyia		1	
Thienemannimyia grp.	4	3	
Labrundinia	11	6	1
EPHEMEROPTERA			
Acerpenna	3	3	

ORDER (Taxa)	RM	SG	NF
Paracloeodes	8	22	3
Procloeon	28	15	27
Heptagenia		1	
Stenacron	1	5	
Stenonema femoratum		1	
Tricorythodes	1		
Brachycercus		1	9
Caenis hilaris		1	
Caenis latipennis	43	24	18
Leptophlebiidae	2		
Hexagenia	1		11
HEMIPTERA			
Corixidae	1	2	3
LIMNOPHILA			
Physella	7	1	1
ODONATA			
Calopteryx	2	-99	
Argia	18	1	
Enallagma	6		
Ischnura	6	1	
Gomphus	-99		5
Progomphus obscurus			3
Somatochlora	-99		
PLECOPTERA			
Neoperla	3	1	
TRICHOPTERA			
Nectopsyche	2		
Oecetis	1		
TUBIFICIDA			
Tubificidae	1	1	5
Limnodrilus hoffmeisteri			1

Aquatic Invertebrate Database Bench Sheet Report

September 15, 2004 - Big Muddy Ck [0418722], Station 2

ORDER (Taxa)	RM	SG	NF
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Hyalella azteca	68	25	3
COLEOPTERA			
Peltodytes			1
Hydroporus	3		1
Berosus			2
Enochrus		1	
Helichus lithophilus	1		
Dubiraphia	1		
DIPTERA			
Tipula	1		1
Anopheles	4		
Forcipomyiinae		62	
Ceratopogoninae	1		1
Simulium	8	4	
Ablabesmyia	1	7	6
Harnischia			1
Procladius			4
Cricotopus/Orthocladius	1	4	
Nanocladius	1	3	
Parakiefferiella		1	
Paraphaenocladius		1	
Mesosmittia			1
Pseudosmittia	1		
Thienemanniella		1	
Chironomus			2
Cryptochironomus			2
Dicrotendipes		12	1
Glyptotendipes	1		
Cryptotendipes			42
Paracladopelma			3
Phaenopsectra		2	
Polypedilum halterale grp			2
Polypedilum convictum grp	1		
Polypedilum fallax grp		1	
Saetheria		1	
Stenochironomus	2	3	
Polypedilum illinoense grp	11	8	2
Polypedilum scalaenum grp		1	
Stictochironomus			1
Cladotanytarsus		3	7
Paratanytarsus	16	6	4
Rheotanytarsus	84	21	24
Stempellinella			14
Tanytarsus	23	64	101
Tabanus	1		
Thienemannimyia grp.	5	4	4

ORDER (Taxa)	RM	SG	NF
Labrundinia	17	13	1
Diptera			3
EPHEMEROPTERA			
Acentrella		1	
Pseudocloeon	26		
Acerpenna	11	6	2
Baetis	1	4	
Paracloeodes	31	20	7
Procloeon	6	11	8
Isonychia	1	-99	
Heptagenia	1		
Stenacron	17	1	
Tricorythodes	18	4	
Brachycercus			1
Caenis latipennis	56	10	24
Leptophlebiidae	9		
Hexagenia limbata		1	11
HEMIPTERA			
Belostoma	-99		
Neoplea	2		
Corixidae			2
Pelocoris		-99	
LIMNOPHILA			
Physella	2		
ODONATA			
Calopteryx	1		
Hetaerina	2		
Argia	29		2
Enallagma	23		
Gomphidae			2
Gomphus		-99	1
Progomphus obscurus		1	-99
Libellulidae	1		
Epicordulia	-99		
Somatochlora	-99		
TRICHOPTERA			
Cheumatopsyche	7		1
Hydroptila	1		
Nectopsyche	4		
Oecetis			1
TUBIFICIDA			
Tubificidae	2	1	1
Limnodrilus hoffmeisteri			1
Enchytraeidae	2	1	
VENEROIDEA			
Sphaeriidae	1		

Aquatic Invertebrate Database Bench Sheet Report

September 15, 2004 - Big Muddy Ck [0418723], Station 3

ORDER (Taxa)	RM	SG	NF
AMPHIPODA			
Hyalella azteca	2	1	2
COLEOPTERA			
Gyrinus	1		
Hydroporus	4	3	
Uvarus	1		
Berosus	1		
Enochrus	1		
Scirtes		1	
DIPTERA			
Tipulidae	3		1
Gonomyia	2		
Ormosia	2		7
Anopheles	4		
Culex	2		
Pericoma	3		
Forcipomyiinae	1	6	1
Ceratopogoninae	1	1	3
Simulium		2	
Ablabesmyia		4	21
Corynoneura			2
Nanocladius		1	
Paraphaenocladius	1	1	
Thienemanniella	1	1	
Cryptochironomus			2
Dicrotendipes			2
Cryptotendipes			1
Paracladopelma			3
Paratendipes			1
Polypedilum halterale grp			6
Polypedilum convictum grp			1
Stenochironomus		11	
Polypedilum illinoense grp	14	6	9
Polypedilum scalaenum grp			1
Cladotanytarsus	2	7	54
Paratanytarsus			4
Rheotanytarsus	3	2	6
Stempellinella			5
Tanytarsus	2	2	51
Chrysops		1	
Dolichopodidae	1		
undescribed Empididae	1		
Muscidae	1	1	
Zavrelimyia	2		1
Thienemannimyia grp.	2		
Labrundinia	1	4	11
Diptera	1		1
EPHEMEROPTERA			
Pseudocloeon	8		

ORDER (Taxa)	RM	SG	NF
Acerpenna	2	1	
Baetis	1		
Paracloeodes	93	25	44
Procloeon	33	15	6
Heptageniidae			3
Heptagenia			1
Stenacron		2	2
Stenonema femoratum			13
Brachycercus			1
Caenis latipennis	6	1	78
Hexagenia			3
HEMIPTERA			
Microvelia	1		
Rheumatobates	1		
Belostoma	2		
Neoplea	1		
Corixidae			1
LIMNOPHILA			
Fossaria	1		
Physella	3	1	
ODONATA			
Enallagma	5		1
Gomphus			1
Progomphus obscurus			1
Erythemis	1		
TRICHOPTERA			
Cheumatopsyche			1
Hydroptila			1
TUBIFICIDA			
Tubificidae	8		3
Enchytraeidae	13	2	1
VENEROIDEA			
Sphaeriidae	1		5

Aquatic Invertebrate Database Bench Sheet Report

March 22, 2005 - Big Muddy Ck [0503007], Station 1

ORDER (Taxa)	RM	SG	NF
"HYDRACARINA"			
Acarina	1		
AMPHIPODA			
Hyalella azteca	27	1	1
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
COLEOPTERA			
Dineutus	-99		
Agabus	-99		
Hydroporus	1		1
Laccophilus	2		
Tropisternus	1		
DIPTERA			
Tipula	-99		
Pilaria		1	
Ceratopogoninae	1	4	7
Ablabesmyia	1		
Procladius			11
Cricotopus bicinctus	5	3	1
Corynoneura	1	7	1
Cricotopus/Orthocladius	31	117	1
Nanocladius	1	1	1
Parametriocnemus		1	
Paraphaenocladius		1	
Hydrobaenus	13	71	19
Thienemanniella	5	13	
Bryophaenocladius			3
Cryptochironomus	1	2	8
Dicrotendipes	2	16	5
Glyptotendipes		1	
Cryptotendipes			1
Paracladopelma		4	4
Phaenopsectra	5	1	
Polypedilum halterale grp			3
Polypedilum convictum grp		2	
Saetheria		2	
Stenochironomus		13	
Polypedilum illinoense grp	4	13	1
Cladotanytarsus			9
Paratanytarsus	92	34	1
Rheotanytarsus	4	7	
Tanytarsus	39	82	198
Chrysops	-99		
Hemerodromia		1	
Zavrelimyia	7		
Thienemannimyia grp.	11	18	
Labrundinia	1		
Diptera			1

ORDER (Taxa)	RM	SG	NF
EPHEMEROPTERA			
Acerpenna		1	
Heptagenia		2	
Stenonema femoratum		2	3
Caenis latipennis	30		23
Hexagenia limbata			9
HEMIPTERA			
Belostoma	-99		
Ranatra fusca	-99		
Trichocorixa	3		8
ODONATA			
Calopteryx	1		
Hetaerina	-99		
Ischnura	2		-99
TRICHOPTERA			
Cheumatopsyche	1		1
TUBIFICIDA			
Limnodrilus hoffmeisteri	3		
Limnodrilus claparedianus	1		
Enchytraeidae			2

Aquatic Invertebrate Database Bench Sheet Report

March 22, 2005 - Big Muddy Ck [0503008], Station 2

ORDER (Taxa)	RM	SG	NF
AMPHIPODA			
Hyalella azteca	17	-99	1
Crangonyx	-99		
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
COLEOPTERA			
Dytiscidae	1		
Hydroporus	5		
DIPTERA			
Tipula	-99		
Ormosia			2
Ceratopogoninae			24
Simulium	3	4	
Ablabesmyia	2	3	3
Cricotopus bicinctus	23	11	4
Corynoneura			3
Cricotopus/Orthocladius	48	127	18
Nanocladius	2		1
Paraphaenocladius	1		2
Hydrobaenus	13	22	67
Thienemanniella	4	10	2
Chironomus			1
Cryptochironomus		1	5
Dicrotendipes		6	2
Paracladopelma		2	3
Robackia			2
Phaenopsectra	3		4
Polypedilum halterale grp		1	12
Polypedilum convictum grp	3		1
Polypedilum fallax grp		1	1
Saetheria	2	1	29
Polypedilum illinoense grp	8	1	3
Polypedilum scalaenum grp			4
Stictochironomus			6
Cladotanytarsus			1
Paratanytarsus	84	38	10
Rheotanytarsus	3	2	
Tanytarsus	38	29	31
Zavrelimyia	3		5
Diamesa		1	
Thienemannimyia grp.	28	10	16
Labrundinia	7		1
Diptera			1
EPHEMEROPTERA			
Acerpenna	18	8	1
Centroptilum			2
Heptagenia	7	4	
Stenacron	3		
Stenonema femoratum	-99		4

ORDER (Taxa)	RM	SG	NF
Stenonema terminatum	1		
Caenis latipennis	64	1	18
Leptophlebia	1		
HEMIPTERA			
Belostoma	-99		
ODONATA			
Argia	1		
Enallagma	2		
Ischnura	2		
Progomphus obscurus			1
Somatochlora	-99		
TRICHOPTERA			
Cheumatopsyche	4	2	
Hydroptila	1		
Nectopsyche	1		
TUBIFICIDA			
Tubificidae			1
Limnodrilus hoffmeisteri		1	
Enchytraeidae		1	4

Aquatic Invertebrate Database Bench Sheet Report

March 22, 2005 - Big Muddy Ck [0503009], Station 3

ORDER (Taxa)	RM	SG	NF
AMPHIPODA			
Hyalella azteca	1	1	3
COLEOPTERA			
Dytiscidae			1
Hydroporus	1		
DIPTERA			
Tipula	-99		
Ormosia			1
Ceratopogoninae	2		8
Simulium		3	
Ablabesmyia	2		6
Cricotopus bicinctus	15	7	1
Corynoneura	2	1	1
Cricotopus/Orthocladius	48	125	15
Eukiefferiella		5	
Nanocladius	3		
Paraphaenocladius		3	
Hydrobaenus	16	8	88
Thienemanniella	4	4	
Cryptochironomus	5	2	7
Dicrotendipes		6	3
Paracladopelma			3
Robackia			1
Nilothauma			1
Phaenopsectra	2		
Polypedilum halterale grp			2
Polypedilum convictum grp	5		1
Polypedilum fallax grp		2	
Saetheria	3	5	39
Stenochironomus		3	
Polypedilum illinoense grp	2	5	1
Polypedilum scalaenum grp			1
Stictochironomus	1		5
Cladotanytarsus			1
Paratanytarsus	56	20	14
Rheotanytarsus	9	6	
Tanytarsus	36	16	20
Chrysops			-99
Hemerodromia		1	
Zavrelimyia			4
Diamesa		1	
Thienemannimyia grp.	12	14	4
EPHEMEROPTERA			
Acerpenna	8	10	

ORDER (Taxa)	RM	SG	NF
Heptagenia		6	1
Stenonema femoratum		2	8
Caenis latipennis	52	5	50
Leptophlebia	-99		-99
Hexagenia limbata			1
LIMNOPHILA			
Lymnaeidae	1	3	3
ODONATA			
Argia			1
Enallagma			-99
Ischnura			1
TRICHOPTERA			
Cheumatopsyche	6	8	2
TUBIFICIDA			
Tubificidae			2
Limnodrilus hoffmeisteri			1
Enchytraeidae	1		
VENEROIDEA			
Sphaeriidae			2

Appendix B
Big Muddy Creek
Fall 2004
Channel Width and Depth Data

Station 1

Transect	Channel Width (ft)	Wetted Width (ft)	Depth of stream at % of wetted width (ft):		
			25%	50%	75%
1	64	55	1.08	0.42	0.42
2	76	37	1.33	1.33	0.58
3	66	42	0.5	1.0	0.83
4	63	50	0.58	0.58	1.0
5	58	49	1.17	1.17	1.75
6	61	52	0.92	0.42	0.42
7	61	50	1.83	1.08	1.0
8	61	47	1.33	0.25	0.5
9	56	47	0.83	0.75	0.58
10	62	48	1.17	0.5	0.33

Station 2

Transect	Channel Width (ft)	Wetted Width (ft)	Depth of stream at % of wetted width (ft):		
			25%	50%	75%
1	53	24	0.58	0.42	0.58
2	64	25	0.75	0.5	0.67
3	45	25	0.17	0.42	0.58
4	41	16	0.33	0.75	0.67
5	44	28	0.5	0.83	0.5
6	48	20	0.25	0.33	0.5
7	50	45	0.75	0.25	0.42
8	48	23	0.83	0.75	0.83
9	49	32	0.08	0.33	0.83
10	50	21	0.75	1.17	0.38

Station 3

Transect	Channel Width (ft)	Wetted Width (ft)	Depth of stream at % of wetted width (ft):		
			25%	50%	75%
1	34	27	0.33	0.25	0.33
2	37	29	0.17	0.17	0.33
3	36	21	0.5	0.42	0.33
4	35	32	0.33	0	0.5
5	31	18	0.67	0.67	0.42
6	32	29	0.75	0.33	0.33
7	25	24	1.25	0.5	0.5
8	30	19	0.75	0.83	0.75
9	47	12	0.42	1.25	1.1
10	40	15	0.67	0.58	0.42